

TRANSPORT OF COAL-TAR DERIVATIVES
IN THE PRAIRIE DU CHIEN-JORDAN AQUIFER,
ST. LOUIS PARK AREA, MINNESOTA

US EPA RECORDS CENTER REGION 5



506871

A Project Proposal

by the

U.S. Geological Survey
St. Paul, Minnesota

August 1980

INTRODUCTION

A coal-tar distillation and wood-preserving plant during 1917-72 in St. Louis Park, a suburb of Minneapolis, Minn., resulted in serious contamination of ground water.

In July 1978, the U.S. Geological Survey, in cooperation with the Minnesota Department of Health, began a two-year project to obtain a detailed understanding of the transport of coal-tar derivatives through the ground-water system in the St. Louis Park area. Hult and Schoenberg (1980) present a summary of the data obtained during the first year of the study and preliminary conceptual models of the mechanisms and pathways of contaminant transport. Hult (1980a) interprets these and additional data in greater detail, and presents the results of preliminary analytical and computer modeling of transport in the Prairie du Chien-Jordan aquifer. Hult (1980b) evaluates the effect of multi-aquifer wells on the spread of contaminants between aquifers.

As stated in the project proposal for the first two-year project (December, 1978, p. 2):

"the problem is complex. Design of effective remedial action and realistic predictions of the results of those actions will require much detailed information and a calibrated three-dimensional flow model coupled with a transport model (SWIP). Calibration requires analysis of data from a significant number and range of measurable hydrologic-stress events which, in turn, commonly requires three to five years of record collection to develop a model of known and acceptable accuracy. The first two-year study [MN 79-061] will provide valuable insight into the problem and will aid decisions on probable continuation of the project for at least two more years. Development and application of a calibrated model to evaluate the possible effects of remedial actions proposed by State and local agencies will require extension of this project."

The two-year project now being proposed is in agreement with the timing and purpose of the project foreseen in 1978 and cited in the previous paragraph, but the scope of the project has been narrowed to best meet immediate needs within anticipated funding.

"However, because of intense local concern, considerable Federal interest, complexity of the problem, and difficulty of effective remedial action, it is anticipated that continued funding will be available. The approach to the problem must therefore balance the immediate needs of the cooperator with the longer-term requirements of a more definitive study." (1978 project proposal, p. 4.)

THE PROBLEM

The major problem is the presence of toxic coal-tar derivatives in water withdrawn by some municipal wells in the area. As early as 1932, the Prairie du Chien-Jordan aquifer, the region's major ground-water resource, contained water with a coal-tar taste at least 3,500 feet from the site. During 1978-80, use of five St. Louis Park municipal wells completed in this aquifer was discontinued because the wells yielded water containing trace amounts of coal-tar compounds, including benzo(a)pyrene, a carcinogen. Each of the five bedrock aquifers in the metropolitan area underlies the site, and each may have been affected to some degree by the contaminants.

The complicated ground-water hydrology, the diverse chemical and physical properties of coal-tar constituents, and the length of time the contaminants have been moving through the ground-water system, have combined to produce a complex distribution of contaminants.

Individual coal-tar compounds differ widely in toxicity and chemical and physical properties. For example, phenol is about 10 million times more soluble in water than benzo(a)pyrene. Differences in solubility cause large variations in the proportion of each chemical that is dissolved into the ground water, remains in a mixture of liquid hydrocarbons, or is sorbed onto geologic materials. The proportions change with chemical concentration, in space, and with time.

Coal-tar derivatives reached the water table by infiltration through the unsaturated zone and at ponds that received surface runoff and process water from the plant. The highest concentrations of contaminants are in the drift beneath and near the site. Parts of this volume of drift contain an undissolved, liquid mixture of many individual coal-tar compounds. In June 1980, a sample of this liquid from a monitoring well completed in the drift at a depth of 50 feet contained 97,000 mg/L total organic carbon. This hydrocarbon fluid has moved vertically downward relative to the direction of ground-water flow because it is denser than water.

Ground water entering the area of the site through the drift is contaminated by partial solution of the hydrocarbon fluids and by release of compounds sorbed on the drift materials. The contaminated water moves laterally to the east and southeast. Water in the drift 4,000 feet from the site contains less than 10 mg/L dissolved organic carbon, but has a distinct "chemical" smell, and contains a large proportion of coal-tar compounds of high solubility relative to compounds of low solubility.

Contaminants entered the uppermost bedrock aquifer, the Platteville aquifer, directly from the drift and have moved at least 7,000 feet from the site. The contaminants reached deeper bedrock aquifers, primarily the Prairie du Chien-Jordan aquifer, through wells that hydraulically connect the aquifers. Coal-tar compounds have moved to a depth of at least 650 feet in the bore of a multi-aquifer well 4,000 feet from the site. Locally, the contaminants have reached the St. Peter aquifer through the Glenwood confining bed and(or) through bedrock valleys where the confining bed has been removed by erosion. In addition, coal-tar has entered the bedrock-aquifer system directly through a spill into a well that was originally drilled to a depth of 909 feet.

The bedrock ground-water flow system is continually adjusting to hydraulic stresses such as ground-water withdrawals and flow through wells that connect more than one aquifer. As these stresses change, the direction and rate of contaminant transport change. Because the upper part of the Prairie du Chien-Jordan

aquifer is a carbonate rock having fracture and solution-channel permeability and low effective porosity, contaminants can move rapidly through this aquifer. Consequently, the concentration and composition of contaminants in water pumped from individual industrial and municipal wells completed in the Prairie du Chien-Jordan aquifer fluctuates with time.

About 80 percent of ground water withdrawals in the St. Louis Park area are from the Prairie du Chien-Jordan aquifer (Hult 1980a). All the municipal wells that have been shown to be contaminated are completed in this aquifer. Therefore, the project being proposed would focus specifically on the Prairie du Chien-Jordan aquifer.

OBJECTIVES

The objectives of the proposed one-year study are to:

1. Develop the ability to predict contaminant behavior in the Prairie du Chien-Jordan aquifer using a computer model.
2. Preserve continuity in the collection of time-series water-level and pumpage data from all aquifers.
3. Provide for consultation with the U.S. Geological Survey by the cooperators and their consultants.
4. Provide for continued geophysical logging and evaluation of multi-aquifer wells as they are located in the field.
5. Continue collection of chemical data needed to ^{refine} ~~replace~~ the understanding of the problem and to calibrate the model. Additional support for chemical analyses will be needed to meet this objective.

The major emphasis in the proposed project is the development of a method for evaluating the effectiveness of measures taken to minimize both the concentration of coal-tar derivatives in municipal wells in the area, and the continued spread of contaminants in the Prairie du Chien-Jordan aquifer. Hult (1980a) has shown that manipulation of withdrawals from industrial and municipal wells, in conjunction with a continued effort to locate, evaluate, and seal multiaquifer wells injecting contaminated water into the aquifer, may be effective in minimizing the concentration of contaminants reaching municipal wells. Preliminary solute-transport computer models of the aquifer that have been developed to date have proven to be a useful tool in evaluating the problem. The proposed project focuses on refining this tool to more adequately reflect actual hydrogeologic conditions.

SCOPE

The proposed project would focus specifically on the Prairie du Chien-Jordan aquifer. However, unless additional support for chemical analyses of water samples is obtained, the proposed project will depend primarily on previous water-quality data, and data which may be obtained by the Minnesota Department of Health during the first 9 months of the project. High priority will be placed on obtaining additional support from Federal, State, and local agencies for chemical analyses. Additional work is needed to (1) establish an intra-laboratory quality-assurance program, (2) define the areal extent of contamination in the aquifer for at least one date, (3) obtain time-series chemical-quality data at critical locations and times with which to attempt calibration of the transport model, and (4) continue identifying additional contaminant compounds in the aquifer which are significant with respect to transport processes or are considered by the cooperators to pose a risk to human health.

Multiaquifer wells are the major pathways of contaminant transport to the Prairie du Chien-Jordan aquifer identified to date (Hult, 1980a; 1980b). Continuing evaluation of multiaquifer wells, in conjunction with the well-abandonment program of the MDH, is within the scope of the proposed project.

Evaluation of other pathways of contaminant transport to the aquifer will depend on previously collected data. Specifically, coal tar entered the Prairie du Chien-Jordan aquifer through a deep well on the site (well W23; "Hinckley well on the site"). The coal tar in the well may be a continuing, significant source of contaminants to the aquifer (Hult, 1978; 1979a; 1979b; 1980a; 1980b; Hult and Schoenberg, 1980). Specific steps needed to evaluate and minimize impact of this source have been suggested to the Minnesota Department of Health. These steps would require additional funding.

In addition, contaminants may be entering the Prairie du Chien-Jordan through the overlying St. Peter aquifer. The mass of contaminants now entering the aquifer through this pathway appears to be small compared to that entering through multiaquifer wells (Hult, 1980a). Installation of additional monitoring wells would be needed to further test this hypothesis.

Continued detailed evaluation of the drift, Platteville, St. Peter, Iron-ton-Galesville, and Mount Simon-Hinckley aquifers is beyond the scope of the proposed project. The scope of the proposed project could be expanded to include additional work over a longer period of time if funding becomes available. The relationship between past projects, the proposed project, and possible future projects is shown in table 1.

Table 1.--Relationship of proposed project to past and possible future projects

USGS project	Dates	Principal objectives	Related activities by other agencies	USGS publications
Project	July 1978-June 1979	Develop a detailed understanding of the transport of coal-tar derivatives through aquifers in the St. Louis Park area.	Well abandon-ment program by MDH	WRI, Hult & Schoenberg, 1980
MN-79-061	July 1979-Sept. 1980			WRI, Hult, 1980a; 1980b
Proposed project	Oct. 1980-Sept. 1982	Refine transport model of the Prairie du Chien-Jordan aquifer.	Design of proposed remedial action by MDH consultant	WRI
Possible future projects	Oct. 1981-Sept. 1982	Continue collection of time-series data in all aquifers. If additional funding becomes available, and contingent on availability of project chief for project work, refine understanding of transport processes and models of the drift, Platteville, St. Peter, Iron-ton-Galesville, and(or) Mount Simon-Hinckley aquifers.	Implementation of remedial action by State and local agencies	WRI
	Oct. 1982-Sept. 1983	Attempt calibration of models based on four years of time-series chemical data and response of the ground-water system to remedial action. Design a long-term monitoring strategy to monitor and evaluate the effectiveness of remedial measures.		Final report, USGS Professional Paper

TIME AND COST SCHEDULE

The costs for this proposed project (Fed FY 81 and 82) will be shared by the Minnesota Department of Health, City of St. Louis Park, Minnesota Pollution Control Agency, U.S. Environmental Protection Agency, and U.S. Geological Survey. Development of the computer model of the Prairie du chien-Jordan aquifer will be completed during FY 81. A report in the USGS Water-Resources Investigations series will be prepared, reviewed, and published during FY 82. The Minnesota Department of Health will provide laboratory water-quality analyses, down-hole television camera surveys, and prepare selected wells for geophysical logging in the amount of \$10,000 in lieu of funds which will be matched by the Geological Survey. The City of St. Louis Park will assist in monitoring pumpage, water levels, and water quality in municipal wells, and will provide landscaping of monitoring-well sites in the amount of \$5,000 in lieu of funds which will be matched by the Geological Survey. Proposed funding is as follows.

Proposed funding in FY 1981—Model development

	Cash	Services	USGS Match	WOTSC ¹	DOTSC ²	Net cash
EPA.....	\$50,000	\$ — ⁵	\$ —	\$ 7,250	\$10,000	\$32,750
SLP.....	5,000	5,000 ³	10,000	1,800	3,000	10,350
MPCA.....	5,000	—	5,000	900	2,000	7,100
MDH.....	5,000	10,000 ⁴	15,000	2,700	4,000	13,300
Totals	65,000	15,000	30,000	12,650	19,000	63,500

¹ EPA = 14.5 percent; others at 9 percent.

² 20 percent of all cash and matching funds; 0 percent on direct services.

³ Assistance in monitoring municipal wells, and well-site landscaping.

⁴ For camera logging of wells and analysis of samples collected by the USGS.

⁵ Value of possible water-quality analyses has not yet been determined.

Itemized expenditures of net cash, FY 1981

Hydrologist GS-11.....	\$24,600
Hydrologic technician GS-6.....	13,900
Computer (50 runs at \$200 and 100 runs at \$40).....	14,000
Equipment purchase and rental.....	6,000
Travel (includes \$1,500 for training).....	2,000
University of Minnesota (adsorption coefficients).....	3,000
TOTAL	63,500

Proposed Funding in FY 1982—Report processing and publication

Hydrologist (1/2-time).....	\$ 13,300
Typing, drafting, reproduction.....	3,200
DOTSC.....	6,250
WOTSC.....	2,250
	<hr/>
Total	\$ 25,000

Project costs in FY 82 would be shared equally by the U.S.
Geological Survey and the cooperators.

REFERENCES

Hult, M. F., 1978, Letter to R. L. Wade: Dated November 16, 1978.

____ 1979a, Letter to R. L. Wade: Dated February 6, 1979.

____ 1979b, Presentation to joint meeting of Twin City Geologists and Minnesota Section of the American Water Resources Association: April 26, 1979, St. Paul, Minnesota.

____ 1980a, Assessment of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota: U.S. Geological Survey Water-Resources Investigations 80-____. (In preparation.)

____ 1980b, Effect of multiaquifer wells on transport of contaminants, southeast Minnesota: U.S. Geological Survey Water-Resources Investigations 80-____. (In preparation.)

Hult M. F., and Schoenberg, M. E., 1980, Preliminary evaluation of ground-water contamination by coal-tar derivatives, St. Louis Park area, Minnesota: U.S. Geological Survey Water-Resources Investigations 80-____. (In review.)

Legislative Advisory Commission Request

See instructions on reverse side before filling out this form.

Department/Agency		Date
Health		October 1, 1980
Title	Amount Requested	No. Personnel Requested
St. Louis Park Water Well Abandonment Program	\$29,640	0
Appropriation Account (APID)	F.Y. 81	
Appropriation Account (APID)	F.Y.	
Type of Request: (check one) <input checked="" type="checkbox"/> Emergency Request — State Funds and Positions <input type="checkbox"/> Federal Grant Approval <input type="checkbox"/> Other LAC Action		

BRIEF SUMMARY OF REQUEST: (See reverse side for items to be included. A Detailed Justification should be attached to this form, when required). Waste from a former coal tar refining and wood treating operation (Reilly Tar & Chemical Corporation) located in St. Louis Park, Minnesota, caused a major contamination of groundwaters with creosote materials. Inasmuch as these groundwaters are extensively utilized as a source for private and community drinking water supplies, the Department of Health requested the Legislature, in 1978, to provide funding for purposes of defining the extent and nature of the contamination and for abandonment of wells which were found to be contributing to the spread of the contamination. In response to the Department's request, Laws 1978, Chapter 793, Sec. 28, Subd. 4, appropriated \$200,000 "for wells, soil and chemical analysis, geological and hydrological studies, well abandonment and laboratory testing for model design." Of this amount, \$70,000 was designated by the Department for use in the well abandonment effort.

The process of identifying wells in the area from old records, securing the approval of landowners of private property, physically locating the unused wells (oftentimes located under existing structures), evaluating their condition, and making arrangements with a private contractor to perform work on the wells, consumed much more time and effort than was initially anticipated. Therefore, it was necessary for the Department to request the Legislature on two occasions to extend the availability of the remaining funds designated for well abandonment. Those requests were approved (Laws 1979, Chapter 336, Sec. 7 and Laws 1980, Chapter 614, Sec. 30).

To date, approximately \$65,500 has been expended under this program and 24 water wells have been investigated, permanently sealed or recompleated for use. The remaining funds will be used to locate a well which is known to exist under a concrete slab in the work area of an operating lead processing plant.

Future abandonment work (requiring several years to complete) will involve approximately 73 wells known or reported to be present in the area. If additional funding (\$29,640) were made available, it would be possible to continue the work on 7 of these wells during the remainder of FY81. The wells which possess the greatest threat to further groundwater contamination are given priority attention. Recent studies by the U. S. Geological Survey indicate that these wells may contribute significantly to contamination of the deeper aquifers.

The State will attempt to recover costs for these mitigative measures through litigation against the Reilly Tar & Chemical Corporation.

I certify that this request for funds has not previously been considered by either the House Appropriations, or Senate Finance Committee, and that the request is submitted in accordance with the guidelines and instructions on the reverse side.

Department Head Signature

Date

Detailed Cost Justification

The amount requested, \$29,640, was derived by estimating the cost of the work that could reasonably be completed by the end of FY81 as follows:

1. Monitor Drill Well

Well requires cleaning out and test pumping. Sealing or recompletion will occur at additional cost after the well has been surveyed. The cost of sealing is included because the well is located in the work area of a plant, although after a survey it may be advisable to complete the well as a monitoring well.

Survey	\$ 400
Excavation - 10 hours @ \$75	750
Remove and haul concrete slab, 10'x12'x8'	890
Clean out well - 160 hours @ \$60	9,600
Grout	6,000
Replacement of slab	900

Estimated Cost: \$18,540

2. Strom Block Well

The well is located under a building. It was reported to be cemented below the floor and we are hopeful that the well is open and in an unobstructed condition. After the well is located, abandonment will take place at additional cost when permission is obtained to seal or recomplete the well as a monitor.

Estimated Cost: \$ 1,000

3. Minnesota Rubber Well

This well was recently located and is reported to have a 12-inch diameter, depth unknown.

Open, survey and test pump	\$ 500
Seal (assuming well is unobstructed)	3,500

Estimated Cost: \$ 4,000

4. Park Pet Hospital Well

Connect to city water supply and seal well.

Estimated Cost: \$ 3,600

5. St. Louis Park Theater Well

Convert to a monitoring well and install pumps.

Estimated Cost: \$ 500

6. Texatanka Well

Convert to a monitoring well and install pumps.

Estimated Cost: \$ 500

7. Chicago-Milwaukee Railroad Well

Locate and seal.

Estimated Cost: \$ 1,500

Total Estimated Cost: \$29,640

DEPARTMENT HEALTH

Office Memorandum

TO : Gordon Meyer
Division of Water Quality
Minnesota Pollution Control Agency

DATE: April 3, 1980

FROM : Pauline M. Bouchard;
and Mike Convery) *MC*
Division of Environmental Health

PHONE: _____

SUBJECT: Remedies Immediately Needed for St. Louis Park Water Supply

Below is a list of steps which could be undertaken in the coming months to rectify the shortage of safe drinking water which the City of St. Louis Park is likely to experience because of contamination of groundwater caused by the former Reilly Tar creosote operation. The list includes both measures to relieve the water shortage which is anticipated for the coming summer and measures which should be undertaken now, to retard the spread of the contamination to nearby water supplies. A shortage of water for the coming summer is anticipated because five of the City's wells (nos. 7 and 9 at Cedar Lake Road and Nevada; nos. 10 and 15 at 29th and Idaho; no. 4 at 41st and Natchez) have been shut down due to the fact that water from those wells contained quantities of PAH compounds which MDH thought were unsafe.

An important consideration which must be taken into account when evaluating the tasks enumerated below, relates to the matter of treatment versus containment. While we are convinced on the one hand that treatment is necessary for the short term, we do not want to focus on treatment at the expense of containment and removal. All of the following steps should be undertaken immediately, if the City is to: 1) provide an adequate summer supply, and 2) prevent deterioration of wells now in use.

1. a) provide all necessary services and equipment (including engineering design, labor and construction) to permit the City to hookup to the Minneapolis water supply and reimburse the City for all of the water which it must purchase from Minneapolis; or
- b) restart wells nos. 10 and 15 and treat these with powdered activated carbon, to safe drinking levels. Only these two are amenable to this kind of treatment, since they are connected to the iron removal plant, where the carbon could also be removed. Current estimated cost of equipment for each well is approximately \$10,000. Operation costs would be extra.

2. Well Abandonment Program (private wells)

Current Status

Twenty-four wells have been sealed, recompleted, and/or investigated at a cost of \$70,000.

Further Work

Further abandonment work will involve 73 wells known to be present or reported in the area. These breakdown as follows:

April 3, 1980

- a) 9 wells - Sufficient information is available on these production wells to let bids for redrilling and sealing.

Estimated cost = \$150,000

- b) 17 wells - Additional information is needed on these wells. These wells must be located, field inspected, cleaned, surveyed by downhole camera, sampled and analyzed. It is difficult to estimate costs due to insufficient information. However, once a well has been located, abandonment usually costs \$1,000-\$5,000.

Estimated range of total costs
\$17,000-\$ 85,000

- c) 23 wells - These wells are located outside the original U.S.G.S. study area. Some of these wells may require redrilling or sealing if the U.S.G.S. study identifies contamination beyond the limits of its study area. Again, the same costs apply as above, excluding location costs.

Estimated range of total costs
\$23,000-\$115,000

- d) 24 wells - These wells have been reported or located since the abandoned well survey was conducted. The minimum costs for these would be:

Estimated range of total costs
\$24,000-\$120,000

- e) Unknown or unreported wells may be contributing to groundwater contamination and the current search program must be continued.

The minimum costs outlined here total \$435,000. However, many wells are located under buildings or may be filled with debris which makes them difficult to locate and repair. These factors can increase the above cost estimates by almost an order of magnitude. Thus, the figures outlined above are conservative.

3. Initiate studies of various methods of treatment for removal of PAHs from drinking water to determine which method is most suitable for the City's purposes. The study would include both a literature review and bench tests. This is essentially the same study as the City is willing to contract out for \$25,000. If the City does let a contract for the study, Reilly could be made to reimburse the City for its costs.
4. Provide portable-unit, powdered activated carbon treatment for wells nos. 7 and 8. Since these are not connected with any treatment plant, all treatment and removal must be done at the well head before the water enters the distribution system.
5. U.S.G.S. Study: This study started July 1, 1978, and involves a determination of extent and magnitude of contamination in the glacial and bedrock aquifers and an analysis of the geology and hydrology of the area. This effort is scheduled for completion in June, 1980. However, further information should be developed as the consultant develops a remedial plan and further monitoring would be extremely useful to better assess contaminant behavior. Some preliminary estimates for further work include:
 - a) Continuation of the water quality monitoring program which involves measuring water quality and piezometric levels in at least 115 wells.

- b) Implementation of a major, full-scale pumping test in each of the two drift aquifers. This is necessary for effective design of a barrier well system, for assessing possible subsidence problems, and for determining the possible magnitude of contaminant movement. This project would include installation of monitoring wells and water level recorders.

\$35,000

- c) Placement of a test core for a relief well immediately adjacent to Well W23, the "Hinckley" well on the former Republic Creosote site. This core will be placed to the bottom of the Prairie-du-Chien Formation and would be used for thorough evaluation of contamination in the Prairie-du-Chien from Well 23 and in monitoring clean-up activities on Well 23. For instance, it may be used to remove contaminants that may be mobilized by cleaning Well 23.

\$61,000

6. Support and expand current testing programs and increase the analytic capability for adequate assessment and monitoring of the St. Louis Park contamination. This program involves analyses of private, commercial, and municipal wells in St. Louis Park and adjacent communities. The program conducted to date has been restricted because of staff and equipment limitations. Most of these analyses have involved PAH determinations. The requirements outlined below are for implementing an extensive and thorough field analytical program.

a) Sample Analyses

- 1) PAH compounds - This would involve sampling approximately 120-150 wells monthly, with some of these being sampled more frequently. This would involve 30-48 samples/week at a cost of \$60.00 per sample.

(\$90,000-\$144,000/yr.)

- 2) Priority pollutants (volatile organics, acid and base/neutral organics) - This would involve a less intensive sampling program, on the order of 100 samples (at \$175/sample)

(\$17,500/yr.)

b) Supplies

solvents, columns, Na_2SO_4 , etc.

\$8,000.00

c) Equipment

- 1) One 31,000 compound library on tape - This is for rapid identification of gas chromatograph/mass spectrophotometer analyses.

\$750.00

- 2) One liquid concentrator and gas chromatograph unit - This is for determination of volatile fractions.

\$3,500.00 & \$8,000.00

- 3) One scanning fluorescent detector - This is for enhanced PAH determination.

\$12,000

d) Staffing

One chemist - analyses and identification \$12,000

One chemist aide - extraction and preparation \$10,000

If this work is contracted out to private labs, 5% should be added to the above cost estimates (other than equipment).

April 3, 1980

7. Determine whether the contaminated wells, because they have been shut off, are contributing contamination to the pumping wells which have not yet shown any contamination. We have reason to suspect that such a process may have resulted in the contamination of well no. 4, which was not contaminated when wells nos. 7, 9, 10 and 15 were shut down. If the shutdown is determined to be contributing to the contamination of wells which were heretofore clean, the wells which have been shut down should be restarted and their waters treated and discharged to an appropriate sewer or surface water body.
8. On the basis of existing information, construct and pump as many barrier wells as are presently known to be necessary, i.e., wells near the most heavily contaminated soils, based on some Barr study data.